ZigBee based Disaster Surveillance Vehicle

Abin Satheesan[1] Rehna Vincent[2]
[1,2]Assistant Professor
[1,2]Department of Electronics and Communication
[1,2]Bannari Amman Institute of Technology Sathyamangalam, Tamilnadu, India

Abstract— The past decades have seen a growing interest in wireless technology and their applications. The evolution of wireless world blasted the unfeasible communications into possible. Here we can see such a system to overcome the moving inability of human being through narrow pipe or narrow explosive areas. This is a vehicle model device which is capable to move through the drainage or narrow pipe to detect the leakage or imperfections in manholes. This system can be used in oil and gas industries to detect the leakage in the narrow pipes where the human intervention is not possible. The main attractive as well as decisive part of this vehicle is Zigbee module. This device will transmit and receive the data between the main stations. This application has taken from the role of ZigBee in the intelligent transportation system.

Key words: WLAN, PHY, MAC, IR

I. INTRODUCTION

In industrial automation products have inevitable role in the petroleum industry and drainage monitoring system. The reason behind this is, human interference is not possible at these places. So we should work on these places to monitor the current status to avoid the catastrophic impact on the atmosphere. At the same time these places are more congested and oxygen free medium. So during these times human movement is impossible. The importance of moving robots will come to the platform on such cases. The ZigBee based surveillance vehicle is a robotic vehicle that is designed to move through narrow pipes and muddy areas to detect the leakage and blocks inside the pipes.

Many wireless and wired communication protocols are available today. At the same time each level have their own security features and error correcting mechanisms. The three significant communication systems are Bluetooth, WLAN and ZigBee. It is observed that all the three technologies coexist at the frequency of 2.4GHz. It can also be observed that the transmission power of Bluetooth system is less as compared to ZigBee and WLAN but the rate of transmission of data packets that is Data rate of Bluetooth is high compressively.

The vehicle which we have introduced here is very compact at the same time it should consume very less amount of power during the time of operation. So ZigBee is more pertinent for this application as compared to others. The sensors and modules are interfaced with PIC 16F877A microcontroller to ensure that the PIC and sensors are successfully connected. If the connection between the sensor and communication modules are perfect, the data can be sent and receive

A. Functional Parts

The functional parts of the system consist of ZigBee, Wireless camera and IR transceiver. These are the base blocks of the system. Each section have crucial role in the operation of the system.

1) ZigBee Protocol

ZigBee devices are used in smart energy, medical and in home automation. In smart energy applications ZigBee products are used to monitor and control use of energy and water, which helps consumers save energy and water and save money too. In medical field it is used to connect unlimited number of health monitoring devices and many more. In home automation it controls domestic lighting, such as switches, dimmers, occupancy sensors and load controllers. It has two bands of operation 868/915MHz and 2450MHz. 868/915 band provides about 20-40Kb/s and 2450MHz band provides about 250 kb/s data rates. In addition to this uses ZigBee end devices can go to sleep mode which saves battery consumption and it also takes care of security of the information owing to security layer. ZigBee IP consists of various protocol layers viz. physical layer(PHY), MAC layer, Network layer and Application layer. IEEE 802.15.4 standard defined ZigBee PHY and MAC specifications. ZigBee alliance specifies network and application layers.

In this era ZigBee has been used as a renewable energy monitoring system to calculate the amount of energy consumed by a particular electric device. Here energy measurement unit is associated with communication devices are used for calculating and sending the data.

2) ZigBee Pro

XBee ZB / ZigBee modules provide cost-effective wireless connectivity to devices in ZigBee mesh networks. Utilizing the ZigBee PRO Feature Set, these modules are interoperable with other ZigBee devices, including devices from other vendors. The most common factor in determining whether to use ZB is the potential need to tie-in with other ZigBee-compatible networks or mesh networking. XBee Pro 802.15.4 OEM RF module is used for long range communication. It has range of 1600 meters in line of sight or 90 meters in indoors or urban area. It is used for embedded solutions providing wireless end-point connectivity to devices. This is an ideal module for robots to PC or robots to robots communication. This XBee wireless device can be directly connected to the serial port (at 3.3V level) of your microcontroller. By using a logic level translator it can also be interfaced to 5V logic (TTL) devices having serial interface. This module supports data rates of up to 115kbps. These modules use the IEEE 802.15.4 networking protocol for fast point-to-multipoint or peer-to-peer networking. They are designed for high-throughput applications requiring low latency and predictable communication timing. The Fig 3 shows the board connections of ZigBee Pro module.

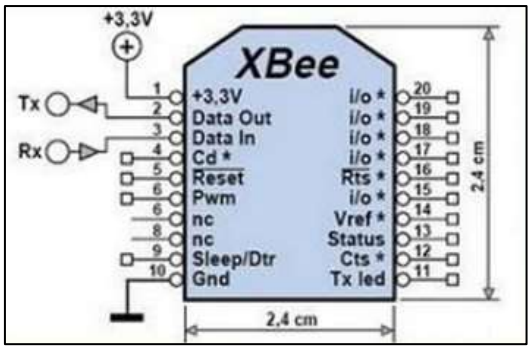

Fig. 3: ZigBee Pro pins

3) Wireless Camera

Wireless camera consists of wireless transmitter and receiver antennas and allows closed circuit cameras or IP security cameras to transmit a wireless signal using a 5.8 Ghz signal up to 4 miles. These systems are used in situations where cable dredging is not practical or is cost prohibitive. The WIFI-EN95610 and WIFI-EH9500 wireless security camera systems are new high performance digital wireless security camera transmission systems. These are our most popular and most recommended systems. These wireless systems offer exceptional video data transmission using 5.8Ghz frequency. They are made for long distance outdoor use with a direct line of sight between the transmitting and receiving antennas.

Fig. 4: Wireless camera and video transmitter

4) IR Transmitter

An infrared transceiver, or IR transceiver, is capable of both sending and receiving infrared data. In other words an IR transceiver is a transmitter and a receiver housed together in one single unit and having circuitry in common. IR transceivers are often used for portable or mobile use. Some transceivers can do both functions at the same time, while other transceivers can only do one function at a time. The device may either have a focused beam, thus requiring it to be in a precise position in order to function properly, or it may be a broader beam, depending on the applications

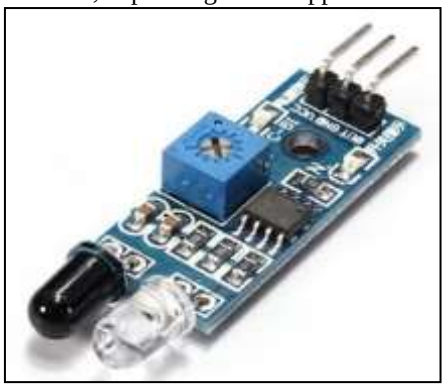

Fig. 5: Infrared transmitter and receiver module.

II. Operation of the System

The system is able to collect the information of fault occurred area and simultaneously it will transmit the data to the computer system to fix the fault in the respective location. This vehicle have three main parts, the first one is a wireless camera, ZigBee and IR transceiver. Each unit have its own responsibility at each level of operation. So we can say this is a combination of optical section, image and wireless communication sections. The wireless camera will capture the images of the interior section to detect the holes or damaged portions inside the narrow path. The captured video will transmit directly to the distant receiver unit for analysis. It is very important to control the direction of vehicle while observing the video from the camera. This part is taken care by ZigBee device. The application software installed in the controller station will control the movements. This movement should be is very crucial to detect the fault. So here the vehicle is able to move forward, backward, Right and Left directions.

The next section will calculate the distance of movement. IR transceiver module has used for this purpose. The calculation of the distance is based on the wheel movement of the vehicle. The IR LED is able to transmit IR beams continuously and the detector is able to receive the reflection from the wheel. After a complete rotation of the wheel the IR receiver will create a count. Based on the time and count the controller unit will calculate the total distance travelled

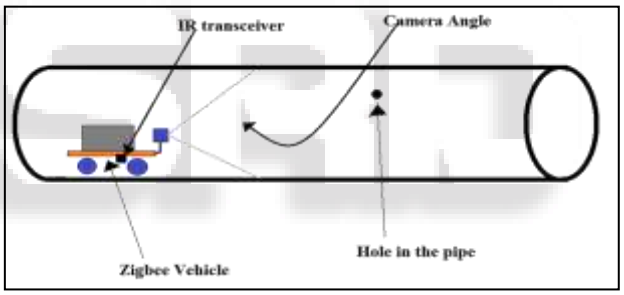

Fig. 6: Movement of vehicle through narrow pipe

Fig 6 shows the movement of vehicle through the narrow pipe and the system is started to observe the imperfections in the pipe. When the system wants to monitor the interior view of the pipe then it will automatically on the wireless camera. This wireless camera is powered by separate NiCd rechargeable battery. Simultaneously the DC gear motors, IR transceiver and ZigBee is powered by 12 V Lead Acid battery. The charge will retain for long time in such type of batteries. ZigBee and internal electronics circuitry need 5V power and sufficient current. This can be supplied by the fixed linear regulators.

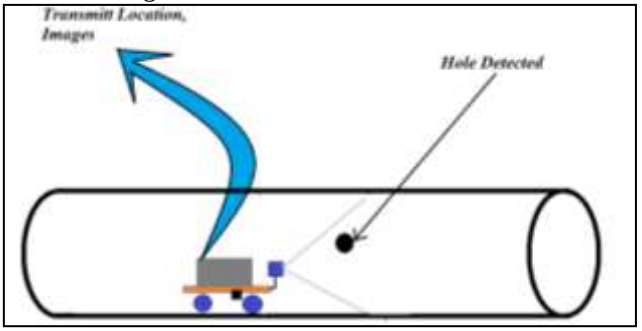

Fig. 7: Hole detection and data transmission

The Fig 7 shows the detection of hole in the pipe. The camera will capture the hole and at the same time it will sent the images to the distant station. The distance travelled can be measured using IR transceiver in the system and that will be displayed on the screen.

All of the required timing and parity checking is automatically taken care of by the ZigBee's UART. Just in case you are producing data faster than the ZigBee can process and transmit it, both ZigBee modules incorporate a clear-to-send (CTS) function to throttle the data being presented to the ZigBee module's DIN pin. You can eliminate the need for the CTS signal by sending small data packets at slower data rates. If the microcontroller wants to send data to transceiver, it will send RTS (Request to Send) signal. If the transceiver is idle it sends CTS (Clear to Send) signal. The RTS and CTS signals are active low. When microcontroller receives CTS command it will send data to the transceiver through DIN pin. The transceiver will send the data to microcontroller through DOUT pin. The communication between transceiver and the microcontroller at the transmitter and receiver is similar. The communication between transmitter and receiver is through RF communication.

The present system can identify the fault occurred in a narrow pipe as well as the exact location of the fault. It is not able to detect the presence of unwanted gas and toxic substances like Carbon monoxide and biogas. So if we can attach the sensors to detect the presence of such items then the efficiency of the system will be more.

III. Analysis

Here we can see the images captured by the wireless camera during the operation through the narrow pipe. The images show the interior of the pipe and while moving through the pipe the camera will continuously send the video without any deviation. The camera is fixed in a flexible base to move in right, left, up and down. If we can attach one more servo motor then the position of the camera can be change according to the observers wish.

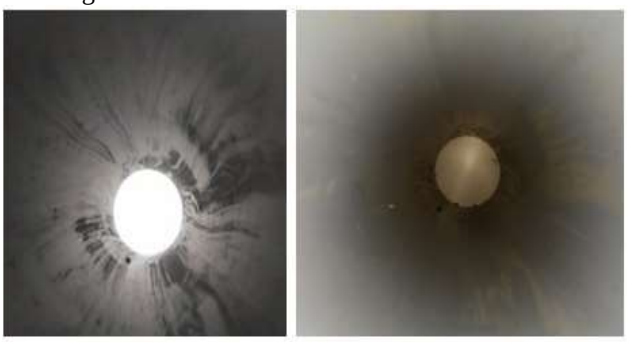

Fig. 8: Images captured by camera

The analysis part consists of comparison between the Bluetooth and ZigBee technology. Here we can understand the main advantages in transmission time and data encoding capacity. Compared to Bluetooth ZigBee is more efficient in both cases.

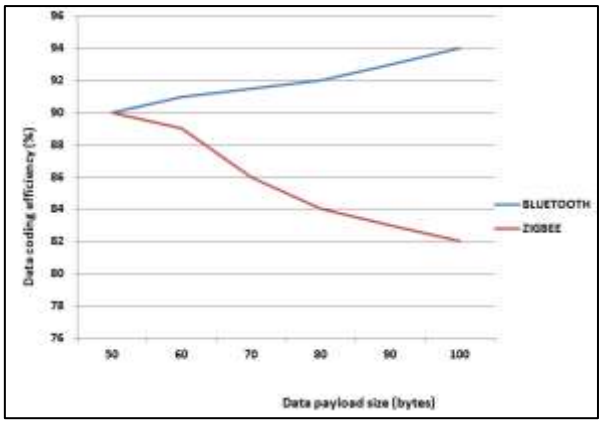

Fig. 9: Data coding efficiency comparison

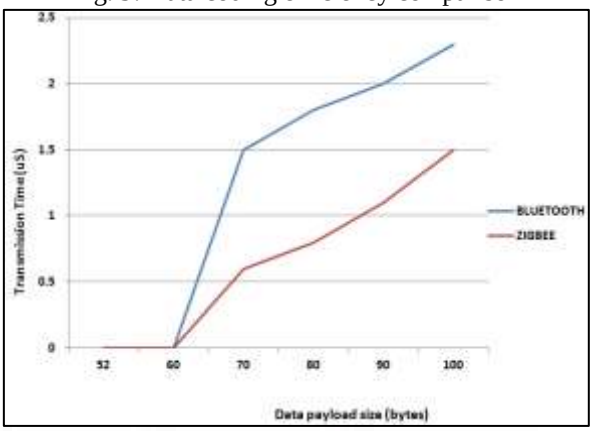

Fig. 10: Data transmission time of Bluetooth and ZigBee

IV. Conclusion

In a nutshell the objectives of the project have been successfully achieved. A wireless monitoring system have been successfully developed using ZigBee technology and the result is satisfactory. The result is this analysis shown that the ZigBee based vehicle can transmit and receive data with less amount of interference as well as the fidelity of the system is high.The system is able to work on the critical environments and systems. The key unit of the robot is the ZigBee module and it is able to control the robot over hundreds of meters. So there will not face any difficulty to get the information about the fault occurred area. It can replace the disadvantages of the conventional transmission protocol like Bluetooth and also it is more reliable than the other system. Here the system can be upgraded with gas sensors and pressure sensors to gather the information about the interior information.

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